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Paedembiidae, a Remarkable New Family and Infraorder of Embiidina from Afghanistan

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The new family Paedembiidae comprises two new genera and species collected on the steppes of western Afghanistan and southern Turkmenistan. Adult males are almost as neotenic as females (Fig. 1). The Afghanistan species is subterranean except when extending its silk galleries into *Artemesia* shrubs to collect leaf fragments to serve as food in the depths of their burrows. Specimens of the Turkmenistan genus and species, described separately by Russian workers, were collected in soil traps. These animals probably have habits similar to those of the Afghanistan species. Additional comments and figures by me, based on a paratype of the Turkmenistan species, have been added to the paper by Gorochov and Anisyutkin (q.v., this issue, p. 795).

Distinctness of the new family is so great that I have decided to place it in a new Infraorder category, Paedembiamorpha. Additional Infraorders will be proposed within Embiidina in my future higher classification of the order.

The new family Paedembiidae is proposed for the most paedomorphic species of the order. Adult males of many other embiids are neotenic in varying degrees, but in all of them the abdominal terminalia attain the same mature development as all other species of the order. In paedembiids, however, we have the first known case of almost complete terminalia neoteny. Males of the Afghanistan species have only a minute process on the inner-base of the left cercus, which can be exposed only by probing (Fig. 2). In some specimens, however, there is no such process, consequently the left and right cerci are perfectly symmetrical.

A transverse fold separates the ninth sternum (hypandrium) (H) from a triangular, fleshy lobe (HP?), which might be considered the caudal process of the hypandrium. However, it possibly could be the sternum of the abdomen's tenth segment, a condition found in no other embiids except possibly the totally unrelated, strictly Australian family Australembiidae. In all other embiids the hypandrium continues caudad as a lobe (HP) without a transverse fold or a dividing membrane. When this lobe in paedembiids is lifted, a small pale amber sclerite and fleshy microlobes are revealed. They may be rudimentary gonapophyses.

The cerci of the Turkmenistan species (see Gorochov and Anisyutkin, this issue) are much shorter than those of the Afghanistan species. The basal segment of the left one is almost globular, slightly in curved and bears a remarkable, slender, inner-basal process. At first it juts ventrad and then abruptly turns diagonally dorsad across the caudal end of the abdomen and finally bends leftward at its apex (see Gorochov and Anisyutkin, this issue, Figs. 1–3). Except for its apex, which is smooth, the outer surface of the process is microspiculated.

INSTITUTIONAL SYMBOLS.— BMNH – British Museum (Natural History) (now Natural History Museum, London); CAS – California Academy of Sciences, San Francisco; USNM – National

Museum of Natural History, Washington, D.C. [formerly United States National Museum]. Other depositories are spelled out.

Explanation of terminalia symbols.— 9 = ninth abdominal tergite; 10 = tenth abdominal tergite; EP = epiproct; H = hypandrium; HP? = hypandrium process, possibly tenth sternum; LC_1 = basal segment of left cercus; LPPT and RPPT = left and right paraprocts.

Paedembiidae Ross, new family

Type genus.— *Paedembia* Ross, gen. nov., by present designation.

Etymology.— The paedomorphic nature of adults of both sexes.

Distribution.— Steppes of western Afghanistan and southern Turkmenistan.

Description.— Males, large, apterous, robust, resembling females, soft-bodied; body length averaging 18 mm. Head elongate-oval, eyes and antennae small with nymphoid segments. Mandibles elongate, incisor tooth of each mandible largest, widely separated from other distal teeth. Mesonotum triangulate, narrowed caudad, with a prominent, longitudinal, medial sulcus. Metanotum simple, quadrate. Basal segment of the tarsus of the mid leg with two ventral rows of very large setae. Basitarsus of hind leg with two, at times flat, ventral papillae as well as large bordering setae. Tenth abdominal tergite broad, lacking cleavages or processes. Ninth sternum (H) quadrate, with a triangular, fleshy lobe (HP?) separated from H by a transverse fold. Paraprocts (LPPT and RPPT) nymphoid, left one slightly larger than the right. Cerci large, at least in the Afghanistan species, very long, directed ventrad instead of caudad and curved forward.

Segments symmetrical, similar in the Afghanistan species except, in most specimens for a small, narrow, non-echinulate, nipple-like process on the inner base of the left cercus (Fig. 2), which may not be visible except by probing. In the Turkmenistan species the basal segment is globular and bears a very elongate, flat sclerotic basal process (see Gorochov and Anisyutkin, this issue, Figs. 1-3), which arcs dorsad and then leftward across the caudal end of the abdomen. It may be a process of the left cercus-basipodite for a shorter, but slightly similar, process arises on the basipodite of a series of new species related to *Oligotoma annandalei* Kapur and Kripalani of India. However, in these species the process is appressed caudad along the inner side of the basal segment of the left cercus. The similarity may be only coincidental and not an indication of a relationship with the Turkmenian species.

Females.— Appearance similar to males but larger in size. Without apparent family-level characters except the mesonotum's longitudinal sulcus.

Discussion.— Because of the nymphoid condition of adult males, especially that of their terminalia, it is presently impossible to determine the relationship of this family to others in the order. In western Asia, the only two stocks are Embiidae (*Parembia persica* [McLachlan]) and Oligotomidae (*Oligotoma nigra* Hagen), but there is no evidence of a relationship to either of these families. Hopefully, less neotenic paedembiids will be collected with characters useful in determining the family's relationships. Molecular analysis may prove useful in a future study of this problem.

The tan coloration resembles that of the many other desert arthropods that shun light, or are nocturnally active. The ventral papillae of the hind basitarsi are flattened and even concave in adult males, but inflated and convex in gallery-confined nymphs. The great size of the ventral setae may aid traction across ground surfaces in search of a mate in another burrow, or during burrow excavation with the mandibles.

Genus *Paedembia* Ross, gen. nov.

Type species.— *Paedembia afghanica* Ross, new species, by present designation.

DISTRIBUTION.— Western Afghanistan.

DESCRIPTION.— Males, very large (body length averaging 18 mm.), robust; apterous; tan, head golden. Cranium large, elongate-oval, nymphoid; eyes small; antennae, as in nymphs throughout the order, are relatively short, with segments small, setae inconspicuous, 23-segmented, segment 3 three times longer than 2 or 4, all segments unicolorous tan; mandibles elongate, apically tapered, slightly extended forward beyond labral margin, slightly carinate longitudinally from dorsal articulation, reddish mahogany with piceous margins, the apical incisor tooth prominent on each mandible, is widely separated from smaller, basal, incisor teeth (two on left mandible, one on right); other mouthparts nymphoid; submentum transversely rectangulate and moderately sclerotized, gular bridge very short. Thorax, legs and abdomen nymphoid; all sclerites pale tan with fine, dark amber setae; all membranes only slightly paler than sclerites; prothorax broad with shallow sulci; mesonotum narrow, triangulate, tapered caudad with a deep, longitudinal, medial sulcus. Basal segment of mid tarsi unusually long with plantar surface flat, lacking setae except for a single row along each side; hind tarsi (Fig. 2) similar but shorter, basal segment slightly constricted medioventrally, all three ventral papillae concave, white, with fine microtrichia. The disc-like surfaces are laterally bordered by very stout dark amber setae. Terminalia (Fig. 2) almost completely nymphoid; tenth tergite, as in nymphs and females, without a trace of cleavages or processes; ninth sternum (H) pale, quadrate, behind which there is a triangular, fleshy lobe (HP?) Separated from H by a transverse fold; paraprocts small, largely covered by HP?. Cerci large, segments elongate, tubular; basal segments similar except in some specimens for a tiny, narrow, dorsally curved process (Fig. 2) projected mesad from inner-base of left segment; this process is concave on its dorsal surface and lacks setae except for a few long ones on its caudal surface; entire inner sides of both left and right basal segments bearing dense, long setae but no echinulations. Cercus-basipodites not conspicuous.

Females, larger than males; mesonotum, as in males, narrowly triangulate, tapered caudad and longitudinally sulcate; metanotum quadrate; generally pale ferrugineous, head darker. Plantar surface of hind basitarsi finely pubescent; bordered on each side by about 12 large, sharp, straight setae; distal plantar surface separated from basal by a low, transverse sulcus, its surface also convex and finely pubescent with inner and outer margins of each with five stout setae in two rows; these two convex surfaces are homologs of the more definite globose, tarsal papillae, occurring in many other embiids. Abdomen nymphoid except for modifications of terminal segments and cerci. Segments 9 and 10 abruptly smaller than others, their terga, as in nymphs, completely lack cleavages or processes; genital aperture is located beneath eighth sternum, which is small, transversely and weakly sclerotized; behind this opening is a narrow, transverse, setose ridge; ninth sternite (H) quadrate, surface smooth, unmodified except for paler, seta-free, almost translucent area on each side of its base. Paraprocts (LPPT) rather small, triangulate, surfaces setose, somewhat depressed. Cerci elongate, cylindrical, evenly sclerotized, directed ventrad and attached close together; setae exceptionally fine and dense, especially on distal segments, vestiture comprised of many evenly-spaced, long setae and many intervening short sensory setae (trichobothria).

Paedembia afghanica Ross, sp. nov.

HOLOTYPE.— Male, in alcohol, CAS. Afghanistan: Mir Pass, 50 km S of Herat (along highway to Kandahar), 1700 m elev., in a subterranean burrow, 2-V-1970 (E.S. Ross).

DESCRIPTION.— As described and figured in the generic treatment.

ADDITIONAL MATERIAL EXAMINED.— ALLOTYPE: Females, as described in the generic treatment, with holotype's data and disposition. PARATYPES: Thirteen adult, topotypic males deposited in CAS, USNM, BMNH, Lund Univ., Sweden and the Russian Academy of Sciences, St. Petersburg. PARALLOTYPES: Eight adult females (CAS). ADDITIONAL RECORD: An adult male from Afghanistan: AA. 1040, Oubeh (90 km E of Herat)

FIGURE 1. Appearance (alive) of an adult male of *Paedembia afghanica* sp. nov. Note peculiar medial mesonotal furrow and the downward projection of the cerci; conditions found only in *Paedembia*. Body length 18 mm.

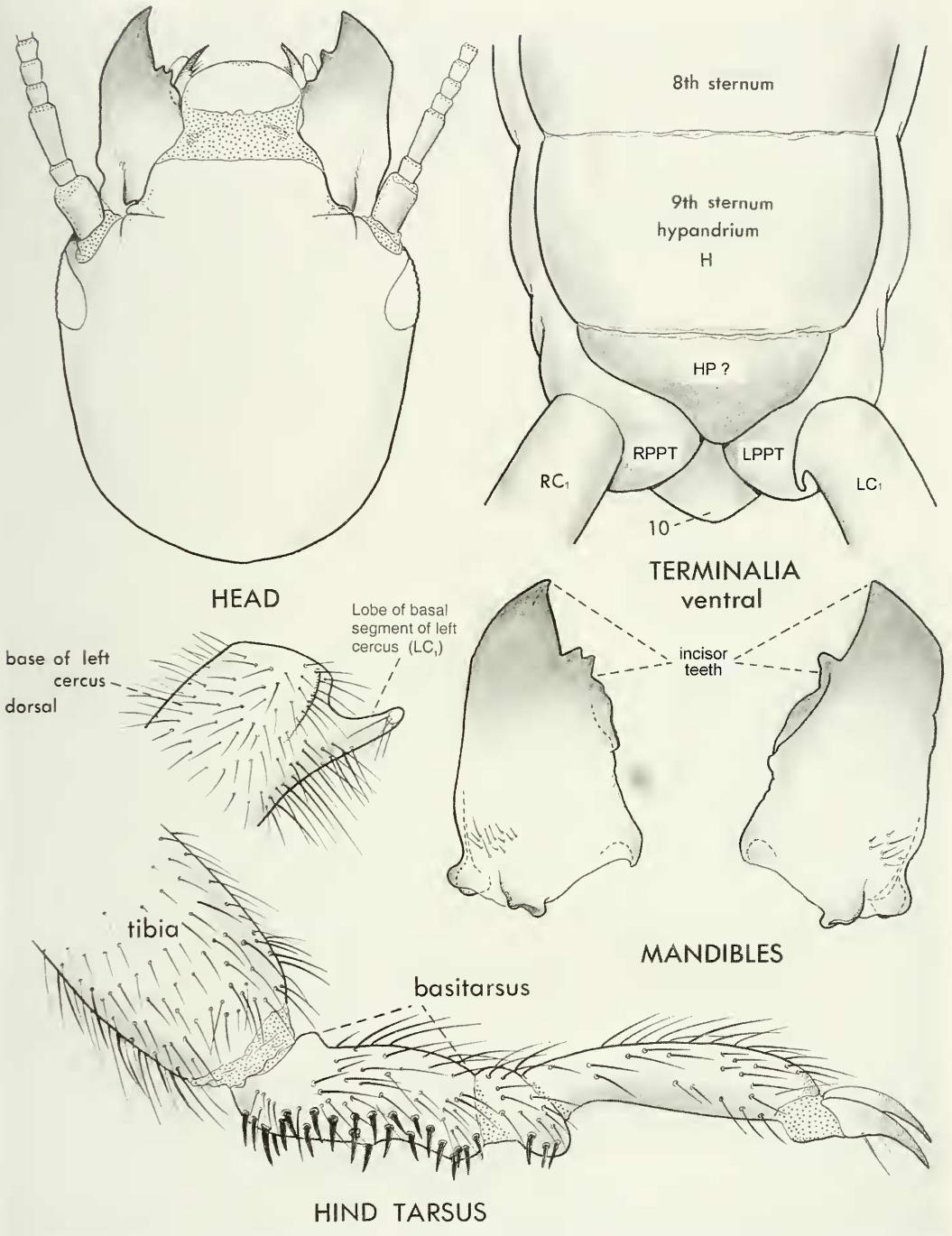

FIGURE 2. Important characters of the holotype of *Paedembia afghanica*. Drawings by E.S. Ross.

"sous pierres pres d'un torrent", 12-VI-1962. (K. Lindberg). Two half grown nymphs were collected in sifted leaves at the same place (CAS).

Discussion.— The late Dr. Lindberg's specimens were sent to me for study. Because of their unusual nature, I took the first opportunity to visit Afghanistan to collect more specimens and determine the species' habits. The occasion took place in the spring of 1970 during a flight stopover while enroute to San Francisco from Africa via the Orient. My successful search and culturing data are detailed as follows:

Field observations.— The type locality is a slope along the north side of a highway near a small, dry, upper tributary of the Rode Gaz, which eventually joins the southwest-flowing Harutrod. The environment (Fig. 3), is arid, grassland with low shrubs grazed by karakul sheep of nomads.

During two short visits, April 30 and May 2, 1970, conditions were prime; foliage green, soil slightly moist. Favorable conditions would soon end and the remaining months of the year would be hot and dry, then bleak and cold during winter.

Turnable surface stones were scarce, but cobblestones imbedded in the silty soil were numerous. I found no evidence of embiids under surface stones in spite of the use of such cover elsewhere in Afghanistan by the "weed" species, *Parembia persica* (McLachlan) and *Oligotoma nigra* Hagen, the most common embiids occurring in Afghanistan and the Middle East.

My search for *Paedembia* was about to be abandoned until unexpectedly I saw a large, grayish white silky gallery extending up from a burrow into twigs and foliage of a low *Artemesia* shrub (Fig. 4). Similar galleries were soon found in other artemesias. Each extended into a burrow, which sheltered an adult male *Paedembia* at a depth of only ten centimeters. A much larger gallery, about 8 cm in diameter, was excavated with difficulty as it penetrated between stones to a depth of about

Figure 3. Author at type locality of *P. afghanica*, 50 km S of Herat, Afghanistan, 1700 m elev., early May, 1970. Vegetation: Artemesia shrubs, bunch grass, iris and other wildflowers.

FIGURE 4. Gallery of *P. afghanica* extended into *Artemesia* shrub to collect leaf fragments to be accumulated in the burrow as a food provision.

forty centimeters (Figs. 5–6). As expected, this gallery contained a very large mature female (body length about 25 mm). At the burrow's end was an accumulation of freshly-collected *Artemesia* leaf fragments.

These and subsequent excavations indicate that broods of *Paedembia* are not gregarious, at least during later stages of development. Apparently each nymph excavates an independent burrow and provisions it with leaf fragments gathered during tolerable conditions above ground in the April-May spring season; otherwise, perhaps only at night or early morning. The pale tan coloration of adults, and the almost white nymphs indicate that the species shuns light and is almost entirely subterranean except for nocturnal above-ground activities. This conclusion is strenghtened by the fact that no embiids were seen in foraging galleries during daytime.

I assume that during most of the year the species survives in its marginal environment by remaining underground. During hot, dry times of the year the surface galleries probably weather away and then there may be no evidence of embiids in the habitat. Because my digging tools were inadequate, I motored northwest to Herat to purchase better equipment, and, while in the vicinity, I checked areas of natural vegetation for *Paedembia* but found only an abundance of *Parembia persica* in conspicuous galleries under stones and in soil cracks. I attributed the absence of *Paedembia* to Herat's lower altitude and greater aridity.

During a short return visit to the *Paedembia* locality, I excavated additional individuals. All late instar nymphs and several adult females were cultured. Each was placed in a separate tube to avoid likelihood of cannibalism. As before, females were found in larger burrows, which I excavated usually at least forty centimeters deep into the soil between firmly imbedded stones. On the ground's surface, several galleries usually radiated outward from a burrow's entrance. One or more of these

FIGURE 5. Author excavating a burrow of a female *P. afghanica*.

extended upward into an adjacent shrub, but others had been spun on the ground's surface and were filled with earth. Apparently they served as "dumps" for excavated soil.

Paedembia suffers predation even within subterranean galleries. For example, once I found a geophilomorph centipede eating an embiid at the bottom of a gallery. Such centipedes are ideally adapted for movement in the galleries and must be important in reducing the embiid species' populations. During my limited observations, I found no evidence of egg or sclerogibbid wasp parasitoids.

During the remainder of my Afghanian tour, I briefly searched other localities along the Herat-Kandahar-Kabul road, as well as regions north of the Koh I Baba (SW end of the Hindu Kush) without again encountering *Paedembia*. I concluded that the species requires access to lower and more southern refugia during long-term cold climatic cycles. It probably is limited to a zone averaging about 1500 meters in elevation, which must be extensive along the southern and western drainage of the Koh I Baba, but one not frequently crossed by major roads. It is likely that paedembiids occur elsewhere in the Middle East, particularly in eastern Iran and possibly western Pakistan. Recently, without success, I searched for *Paedembia* in steppe habitats in southcentral Turkey. A wider distribution of the family is borne out by the surprising discovery of a new species in Turkmenistan (see Gorochov and Anisyutkin, this issue).

FIGURE 6. Burrow of a female *P. afghanica* partly excavated; extends to a depth of forty centimeters.

LABORATORY CULTURING.— In San Francisco, several *Paedembia afghanica* cultures were maintained. Some nymphs simply transformed into adult males and after presumed mating, they were preserved as specimens. Most nymphs died and it was apparent that the species has very low culture vigor.

By July 15, 1970 only two adult females remained alive in spite of careful culture maintenance. Fortunately, one of these produced several first instar nymphs. These were very active and did not spin individual galleries, as is the habit of all other immature embiids. The small nymphs simply crowded just within the entrance of the parent's gallery. On July 23rd about twenty of the small nymphs were seen aimlessly moving about on the upper surface of the culture. Even a slight disturbance caused them to retreat rapidly into an open maternal gallery.

By August 4th the nymphs were about 8 mm in length and continued to walk freely on the inner walls of the maternal gallery. At this stage some of them had begun to spin "personal" galleries to reach food (the culture media consisted of fragmented, dead, California live oak leaves). On August 12th the parent female and twenty nymphs were transferred into a larger container with an abundance of media. The parent female promptly made a linear gallery and lined its upper end with small fragments of fresh Romaine lettuce (which I normally add to a culture's surface as a diet supplement). Obviously, this was a continuance of the food-provisioning habit observed in the field.

By September 24th, nymphs were 12 to 18 mm in length, sluggish and secretive. At this stage they exhibited the triangular, mesonotal outline and longitudinal sulcus, a feature found in no other species of the order. All were creamy white in color.

Because of crowding and consequent increased danger of cannibalism, the adult female was removed on August 31st and preserved. The brood slowly developed during the next year (1971).

Some matured in summer, most others as late as October. I assume that maturity would normally take place in the field during May or June. I had hoped to culture the species for several generations but the presumably-mated females of the 1970–71 brood died one by one without laying eggs. The last survivor died late in January, 1972.

Acknowledgements

Credit and thanks are due to the late Dr. K. Lindberg of Sweden for collecting and sending to me a few paedembiids, including an adult male, he collected near Herat, Afghanistan. My wife, Sandra, assisted my successful search for additional specimens. Dr. A.V. Gorochov and L.N. Anisyutkin of St. Petersberg's Russian Academy of Sciences kindly called my attention to the related, but very distinct species from Turkmenistan and sent me a potential paratype of it. I also thank Norman Penny and Alan E. Leviton of the California Academy of Sciences for reviewing my manuscript.

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